United States Patent [19]
Iwata
[11] Patent Number: 4,691,807
[45] Date of Patent: Sep. 8, 1987

[54] **ELEVATOR CONTROL APPARATUS**

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[21] Appl. No.: **836,522**
[22] Filed: **Mar. 5, 1986**
[51] **Int. Cl.**[4] **B66B 5/08**
[52] **U.S. Cl.** **187/117**
[58] **Field of Search** 187/29, 117

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Attorney, Agent, or Firm—Leydig, Voit & Mayer

[57] **ABSTRACT**

An elevator control apparatus for controlling operation of a cage in an elevator system in which a normal speed command signal is generated having a normal pattern providing gradually decreasing terminal speed as the cage approaches a level of a terminal floor; a terminal-floor slowdown signal is generated having a normal pattern generally similar to the normal pattern of the normal speed command signal and separated therefrom by a magnitude determined by a bias value; the normal speed command signal is chosen as a final terminal slowdown command signal for controlling terminal speed of the cage when, based on comparing the command signals, the normal speed command signal is less than the terminal-floor slowdown command signal, or the terminal-floor slowdown command signal is chosen as the final terminal slowdown command signal for controlling terminal speed of the cage when, based on comparing the command signals, the normal speed command signal is not less than the terminal-floor slowdown command signal; and the terminal-floor slowdown command signal is corrected when chosen as the final terminal slowdown command signal by changing the bias value used in generating the final terminal-floor slowdown command signal; whereby the final terminal slowdown command signal follows at least a final portion of the normal pattern of the normal speed command signal.

7 Claims, 8 Drawing Figures

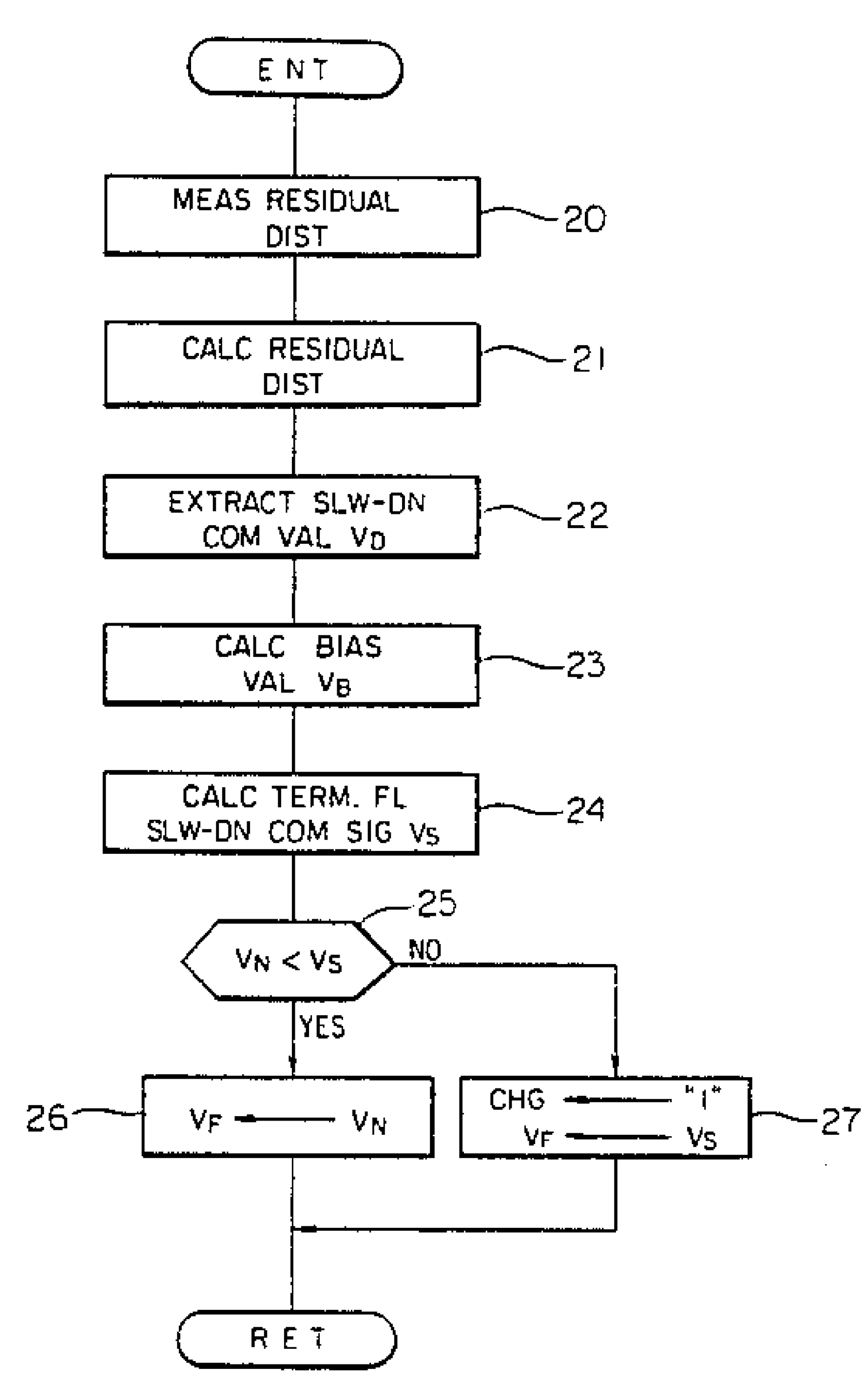


FIG. 1

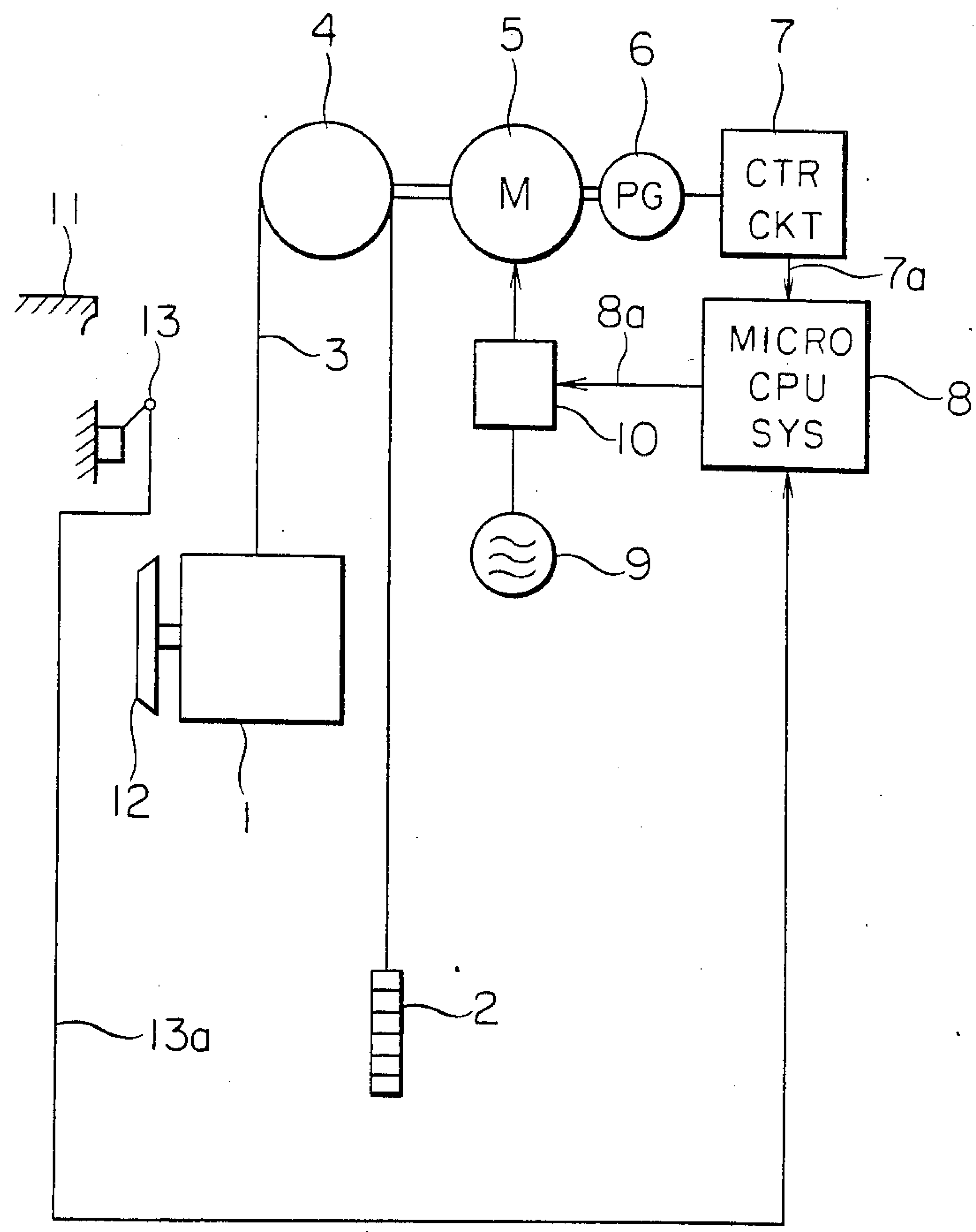
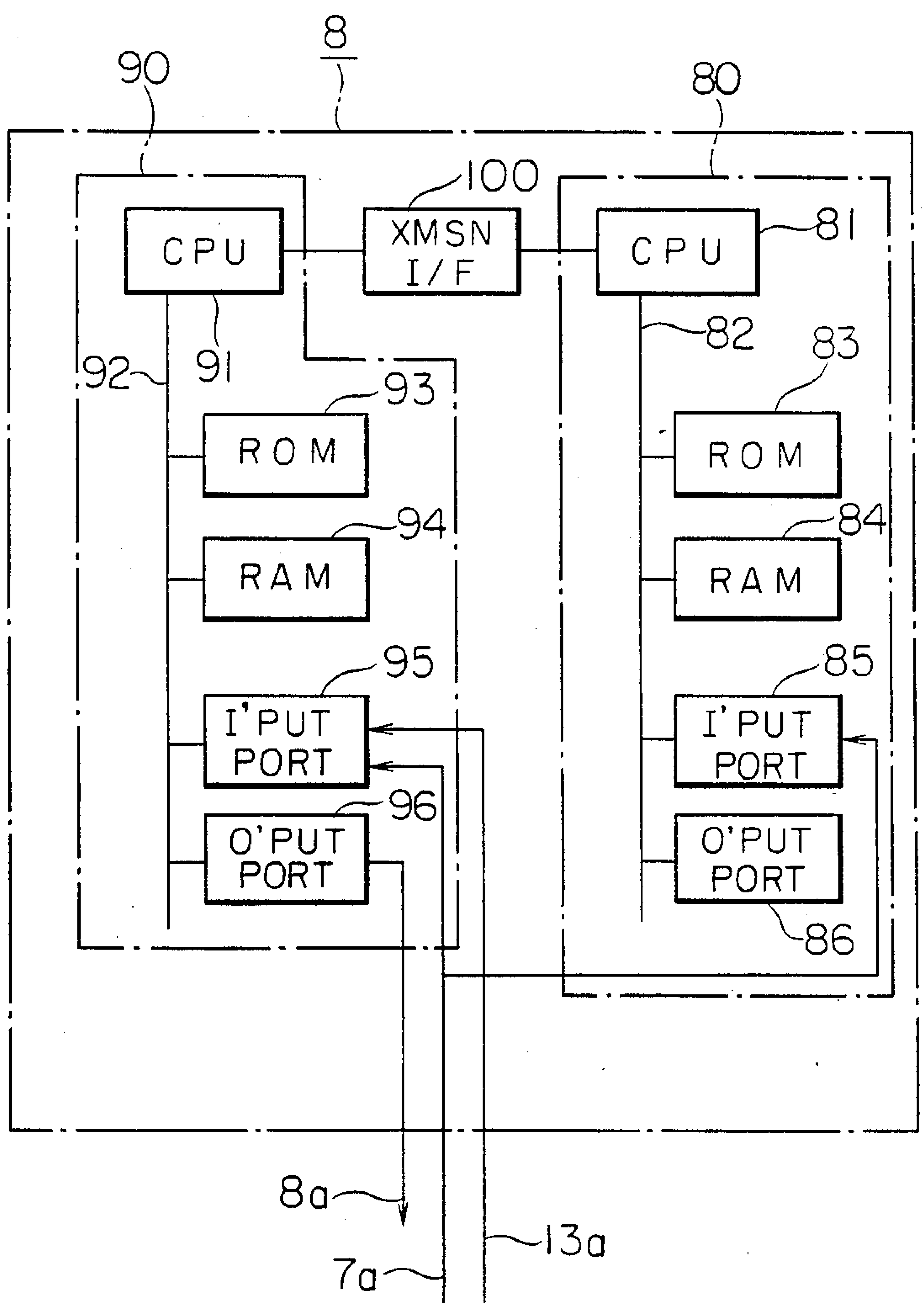


FIG. 2



8
90
80
100
XMSN I/F
CPU
CPU
81
82
83
91
92
93
ROM
ROM
94
84
RAM
RAM
95
85
I'PUT PORT
I'PUT PORT
96
O'PUT PORT
O'PUT PORT
86
8a
7a
13a

FIG. 3 PRIOR ART

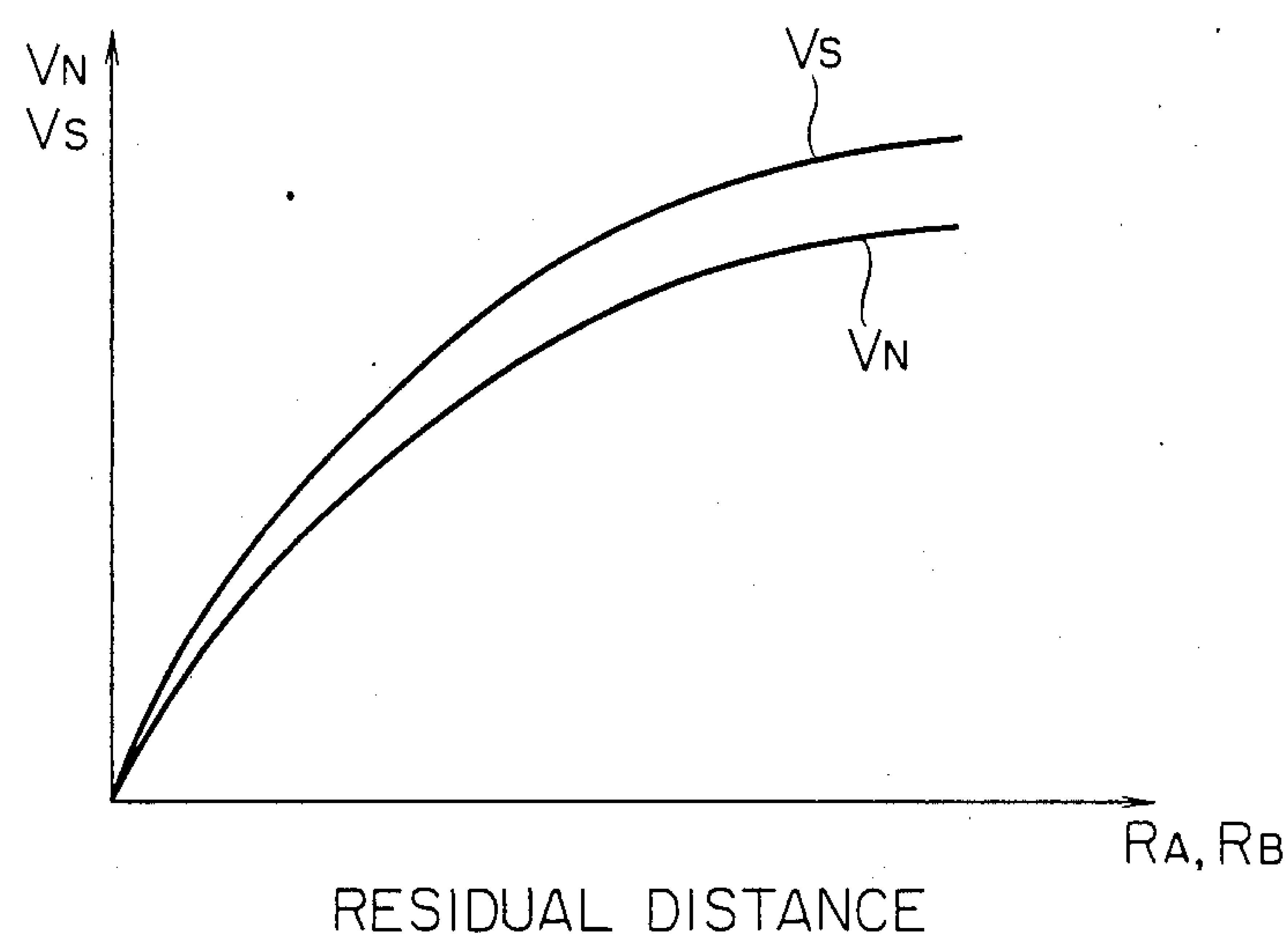


FIG. 4 PRIOR ART

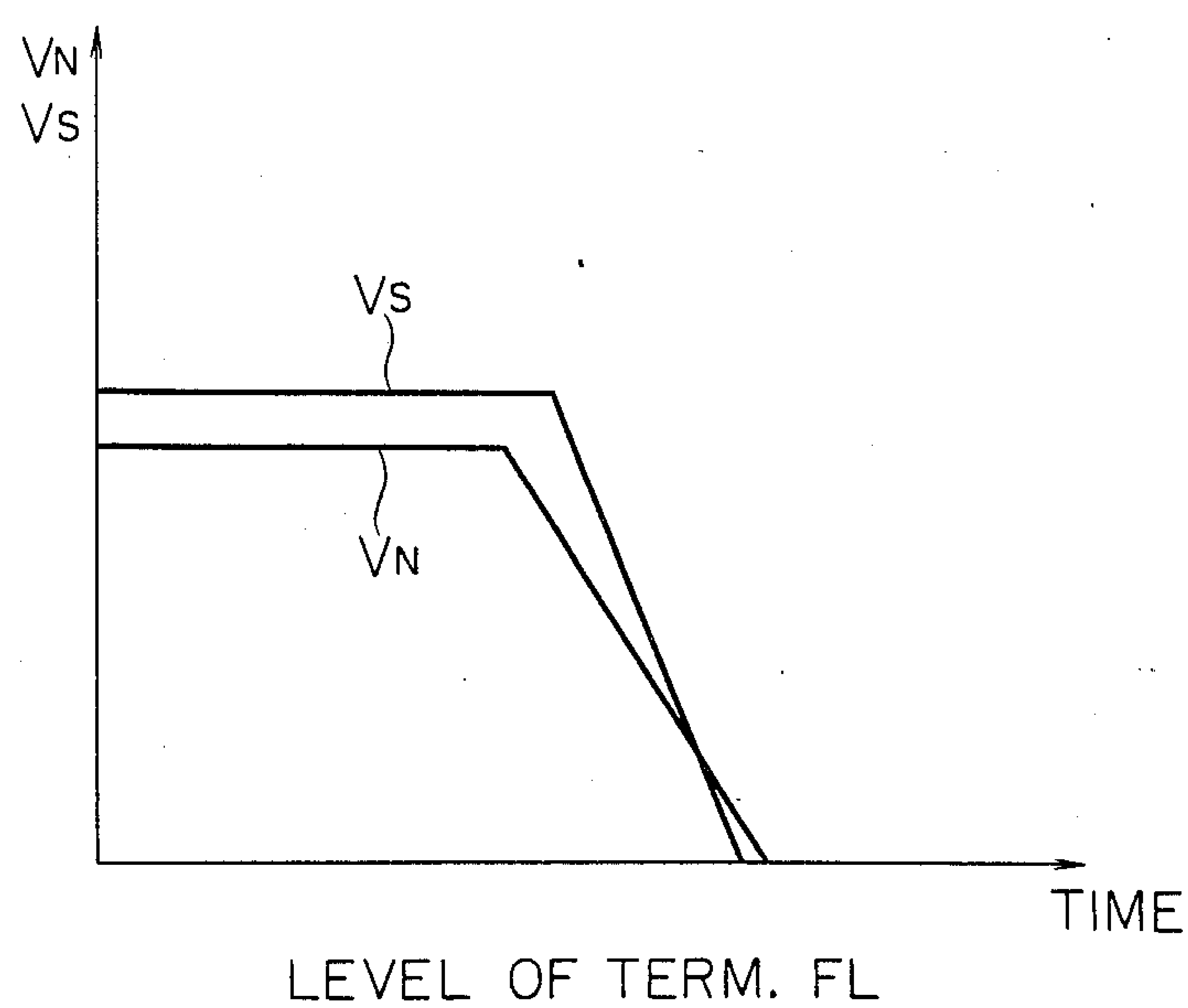


FIG. 5

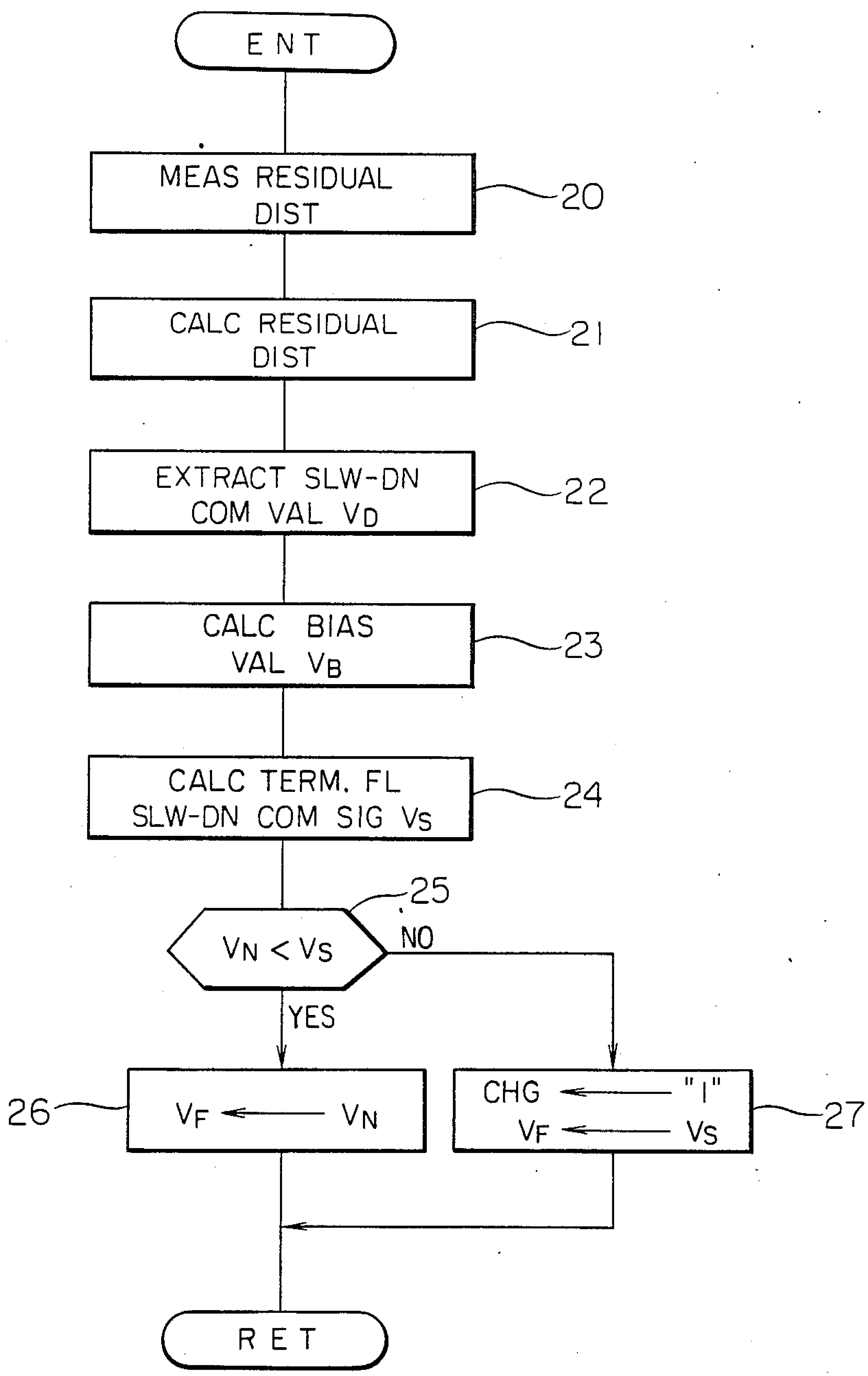

ENT
MEAS RESIDUAL DIST
20
CALC RESIDUAL DIST
21
EXTRACT SLW-DN COM VAL V_D
22
CALC BIAS VAL V_B
23
CALC TERM. FL SLW-DN COM SIG V_S
24
25
$V_N < V_S$
NO
YES
26
$V_F \leftarrow V_N$
CHG ← "1"
$V_F \leftarrow V_S$
27
RET

FIG. 6

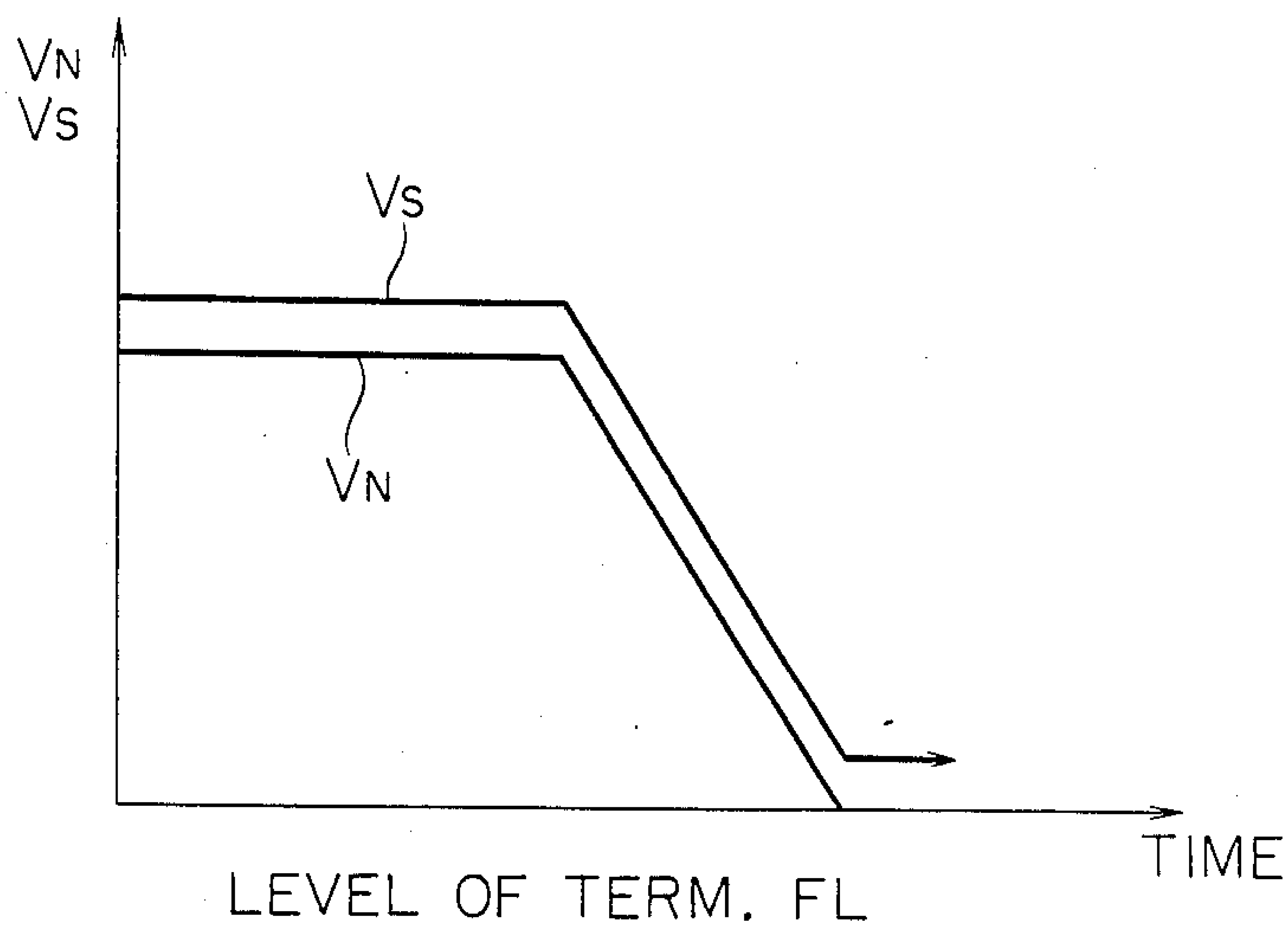

VN
Vs
Vs
VN
TIME
LEVEL OF TERM. FL

FIG. 7

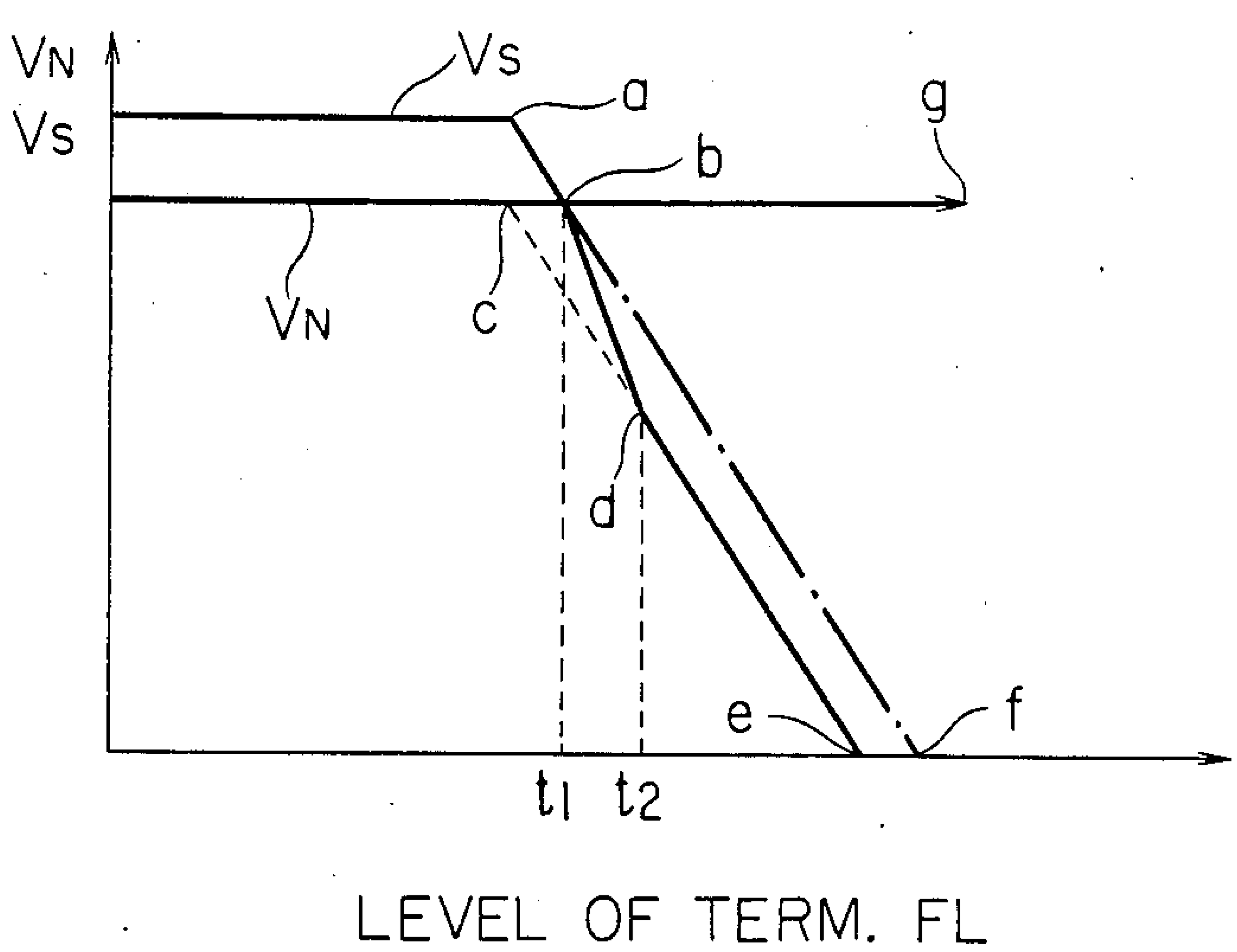
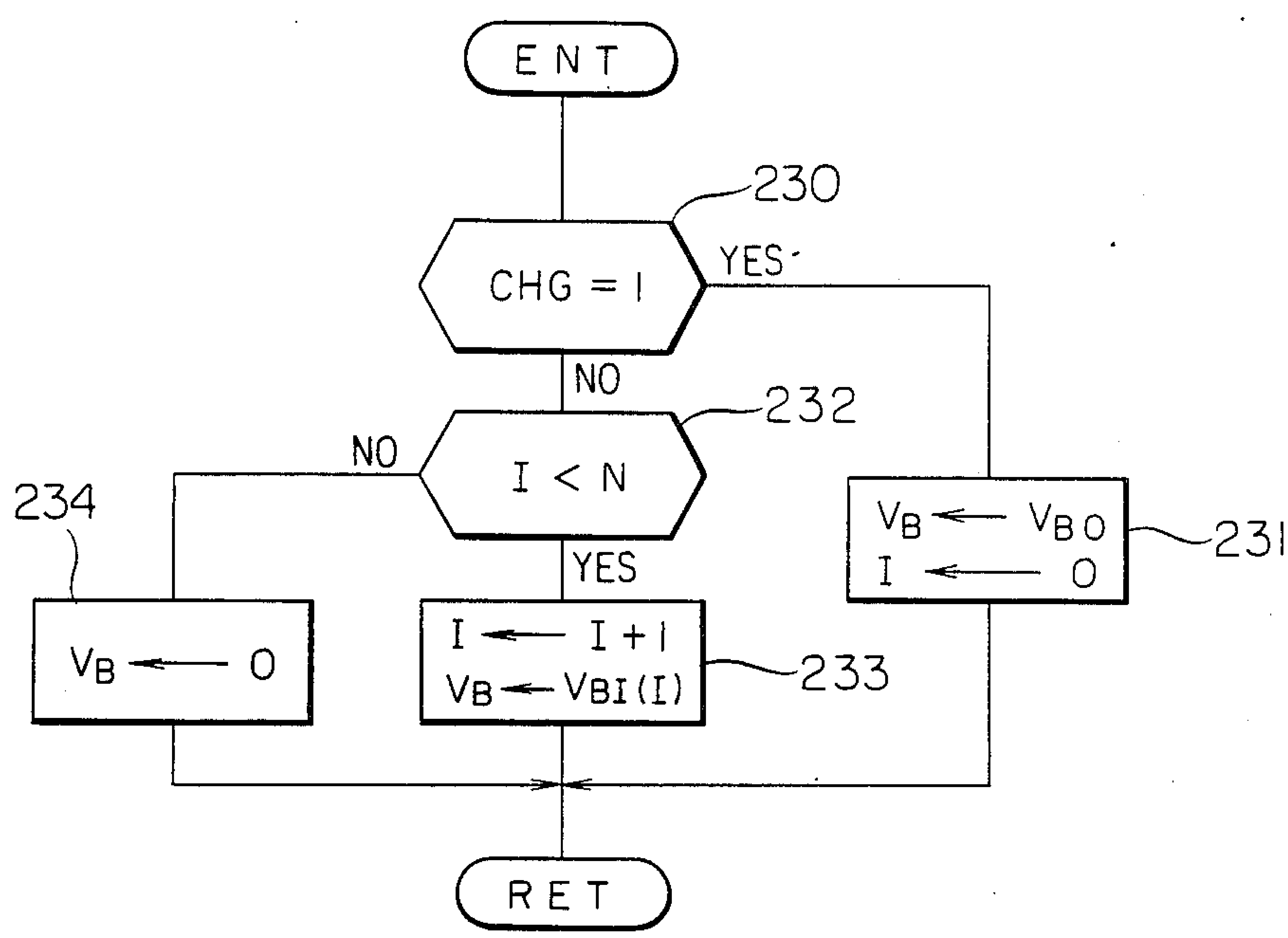

VN
Vs
Vs
a
b
g
VN
c
d
e
f
t1
t2
LEVEL OF TERM. FL

FIG. 8


ENT
230
CHG = 1
YES
NO
232
I < N
NO
YES
234
$V_B \leftarrow 0$
$I \leftarrow I+1$
$V_B \leftarrow V_{BI(I)}$
233
$V_B \leftarrow V_{B0}$
$I \leftarrow 0$
231
RET

ELEVATOR CONTROL APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to a control apparatus for elevators, and more particularly to an elevator control apparatus which generates a terminal floor deceleration command signal.

A prior art elevator control apparatus will be described with reference to FIGS. **1-4**.

FIG. **1** shows a diagram of the overall elevator control apparatus, and concerns the prior-art apparatus and the apparatus of the present invention. Numeral **1** designates a cage, and numeral **2** a counterweight. A rope **3** is wound round a sheave **4**, and the cage **1** and the counterweight **2** are respectively suspended from one end and the other end of the rope **3**. Numeral **5** indicates an induction motor which drives the sheave **4**, numeral **6** a pulse generator which generates pulses proportional to the movement distance of the cage **1** on the basis of the rotation of the motor **5**, numeral **7** a counter circuit which counts the pulses from the pulse generator **6**, and numeral **8** a microcomputer system which receives the pulse count value **7***a* of the counter circuit **7** to calculate a residual distance by way of example. Shown at numeral **9** is a three-phase A.C. power source. Numeral **10** indicates a power conversion device which converts three-phase alternating current into electric power suitable for the speed control of the elevator, and to which a command signal **8***a* from the microcomputer system **8** is applied thereby to control the torque and rotational frequency of the motor **5**. Numeral **11** denotes the plane of a terminal floor, and numeral **12** a cam mounted on the cage **1**. A terminal position detector **13** is disposed in a hoistway, and an output signal **13***a* delivered therefrom is input to the microcomputer system **8**.

FIG. **2** shows the details of the microcomputer system **8**. This microcomputer system comprises first and second microcomputers **80** and **90**. The first microcomputer **80** includes a CPU **81**, a ROM **83**, a RAM **84**, an input port **85**, and an output port **86** which the connected to each other through a bus **82**. The input port **85** is supplied with the pulse count value **7***a* of the counter circuit **7**. The microcomputer **80** thus arranged performs the running control and sequence control of the cage **1**, and generates a normal speed command signal V_N being the ordinary speed command signal of the cage **1**. The normal speed command signal V_N has a relation of $V_N=\sqrt{2\beta_A R_A}$ at a constant deceleration β_A in correspondence with a residual distance R_A to a scheduled arrival floor. In addition, the residual distance R_A is calculated on the basis of the pulse count value **7***a* of the counter circuit **7**.

Similar to the first microcomputer **80**, the second microcomputer **90** includes a CPU **91**, a ROM **93**, a RAM **94**, an input port **95**, and an output port **96**, all connected to each other through a bus **92**. The input port **95** is supplied with the pulse count value **7***a* of the counter circuit **7** and the output signal **13***a* of the terminal position detector **13**. The second microcomputer **90** thus arranged generates a command signal **8***a* for controlling the rotational frequency and torque of the motor **5** This command signal **8***a* is delivered from the output port **96** to the power conversion device **10**.

When, when the cage **1** has approached the terminal floor, the second microcomputer **90** receives the output signal **13***a* of the terminal position detector **13** and sets a residual distance R_B. Thenceforth, it calculates the residual distance R_B on the basis of the pulse count value **7***a* of the counter circuit **7**. On the basis of this residual distance R_B, a terminal-floor slowdown command signal V_S is calculated in accordance with $V_S=\sqrt{2\beta_B R_B}$. β_B is a constant deceleration in accordance with the residual distance R_B and is greater than β_A.

The normal speed command signal V_N calculated by the first microcomputer **80** is fed into the CPU **91** of the second microcomputer **90** through a transmission interface **100** which connects the respective CPU's **81** and **91** of the first and second microcomputers. The command signal V_N and the terminal-floor slowdown signal V_S are compared in the CPU **91**, and the smaller one is used as the final speed command signal. On the basis of this speed command signal, the command signal **8***a* for the power conversion device **10** is delivered through the output port **96**.

Owing to the control apparatus for such a construction, even when the normal speed command signal V_N has not lowered due to any abnormality in spite of the approach of the cage **1** to the terminal floor **11**, the cage **1** can be safely decelerated by the terminal-floor slowdown command signal V_S so as to arrive at the terminal floor.

FIG. **3** is a diagram in which the relationship between the normal speed command signal V_N calculated by the first microcompuer **80** and the terminal-floor slowdown command signal V_S calculated by the second microcomputer **90** is expressed in correspondence with the residual distances R_A and R_B. As seen in FIG. **3**, V_N decreases at the constant deceleration β_A, and V_S decreases at the constant deceleration β_B. In addition, V_N and V_S become very close for small values of the residual distances.

In this regard, the microcomputers **80** and **90** usually have unequal calculation cycles, and the installation error of the terminal position detector **13** and the response delay thereof are involved, so that the residual distances R_A and R_B become $R_A \neq R_B$.

Near the level of the terminal floor, accordingly, $N_N > V_S$ can occur as shown in FIG. **4** on account of the difference of the calculating cycles, etc., and the terminal-floor showdown command signal V_S is selected in spite of the normal speed command signal V_N being correct. This has led to the problems that comfort in ride becomes worse near the levels of the terminal floors than at intermediate floors, and that the accuracies of floor arrival worsen.

SUMMARY OF THE INVENTION

This invention has the objective of overcoming the problems of the prior art mentioned above, and has for its object to provide a control apparatus for an elevator in which, when a normal speed command signal is correctly decreasing, a terminal-floor slowdown command signal is prevented from being erroneously selected, thereby to prevent the worsening of comfortable ride and floor arrival accuracies in the case of running to terminal floors.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a general arrangement diagram of elevator control apparatuses according to the prior art and according to this invention;

FIG. **2** is a block diagram of a microcomputer system in each of the apparatuses;

FIGS. 3 and 4 are diagrams for explaining the operations of the prior-art elevator control apparatus;

FIG. 5 is a flow chart for generating a terminal-floor speed command, showing an example of the elevator control apparatus according to this invention;

FIGS. 6 and 7 are diagrams for explaining operations in this invention; and

FIG. 8 is a flow chart showing in detail a bias value calculating step 23 in the flow chart of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Now, an embodiment of this invention will be described with reference to the drawings.

The general construction of the elevator control apparatus according to this invention is similar to the construction shown in FIG. 1. The block arrangement of the microcomputer system 8 for generating the terminal-floor slowdown command signal is also similar to the arrangement shown in FIG. 2, but the point of difference of the invention from the prior art explained with reference to FIG. 2 resides in the processing function of the second microcomputer 90 by which the selection of the terminal-floor slowdown command signal is avoided when the normal speed command signal is correctly decreasing. Accordingly, the embodiment of this invention shall be described by utilizing the symbols of the various portions shown in FIGS. 1 and 2.

FIG. 5 shows a flow chart of a processing routine for generating the terminal-floor slowdown command, furnished with the above processing function of this invention. A program for the process of calculation is stored in the ROM 93 of the second microcomputer 90 within the microcomputer system 8.

Referring to FIG. 5, a processing step 20 serves to set the residual distance. At this step, the output signal 13*a* of the terminal position detector 13 provided when the cage 1 has approached the level of the terminal floor 11 is fed into the CPU 91 through the input port 95, whereby the residual distance to the terminal floor is initialized. At the next processing step 21, the pulse count value 7*a* being the output signal of the counter circuit 7 is subtracted from the residual distance set by the processing step 20, thereby to obtain the residual distance R_B in each calculating cycle of the microcomputer 90.

The next processing step 22 executes a process in which a slowdown command value V_D corresponding to the residual distance R_B calculated by the step 21 is extracted from the ROM 93. Here, the slowdown command values V_D corresponding to the residual distance values R_B to be provided every calculation cycle are stored as $V_D=\sqrt{2\beta_A R_B}$ in the form of a table within the ROM 93.

When the process of the step 22 has ended, the control flow shifts to the next step 23 which executes the calculation of a bias value V_B. More specifically, when the relationship between the normal speed command signal V_N and the terminal-floor slowdown command signal V_S has become $V_S \geqq V_S$ near the level of the terminal floor and the speed command signal V_S has been selected, the selected V_S signal is corrected by the processing means under control of the program steps 24 and 27 so that the final speed command signal F is the signal V_S corrected in such a way as to change to the pattern of the normal speed command signal V_N illustrated in FIG. 7, following the intermediate segment b-d until the signal V_S joins at the point d the normal pattern c-d-e of the normal speed command signal V_N and then follows the same final pattern segment d-e as the normal speed command signal V_N. By following the pattern c-b-d-e, the corrected final command signal V_S is determined by calculation to follow a pattern which provides a comfortable ride and high floor arrival precision. To this end, in the case where $V_N \geqq V_S$ due to an abnormal operation, the bias value V_B is extracted from the ROM 93 so as to gradually decrease from V_{BO} (constant value) in succession in time correspondence. On the other hand, when $V_N < V_S$ holds, the bias value V_B is maintained at the constant value V_{BO} set in advance.

The bias value V_B to be extracted in time correspondence are stored in the form of a table within the ROM 93.

A step 24 succeeding the step 23 is a routine for calculating the terminal-floor slowdown command signal V_S. Here, the process $V_S \leftarrow V_D + V_B$ of adding the slowdown command value V_D extracted at the step 22 and the bias value V_B extracted at the step 23 is executed to obtain the terminal-floor slowdown command signal V_S.

Subsequently, the control flow shifts to a step 25, which compares the terminal-floor slowdown command signal V_S and the normal speed command signal V_N to decide whether or not $V_N < V_S$ holds. When $V_N < V_S$ holds, the control flow shifts to a step 26, which executes a process $V_F \leftarrow V_N$ to make the normal speed command signal the final speed command signal V_F. More specifically, in the case where $V_N < V_S$ holds, the terminal-floor slowdown command signal V_S ought not to be selected. As V_N is correctly decreasing and follows the normal pattern as shown, the terminal-floor slowdown command signal V_S which is $V_D + V_{BO}$ follows a normal pattern generally similar to the normal pattern of the normal speed command signal V_N, as shown in FIG. 5, and is greater than V_N by V_{BO} (the patterns are shown separated by a magnitude determined by the bias value V_{BO}) even when the cage 1 has come to the vicinity of the level of the terminal floor 11, so that V_S is not selected erroneously.

On the other hand, when the step 25 has decided that $V_N < V_S$ does not hold, namely, that $V_N \geqq V_S$ holds as illustrated in FIG. 7, the control flow shifts to a step 27 at which a flag CHG is set to "1" and at which the selected terminal-floor slowdown command signal V_S is corrected so as to become the final speed command signal V_F to provide a comfortable ride and to increase the floor arrival accuracy. More specifically, when the flag CHG has been set to "1", the microcomputer 90 executes at the step 22 the process in which the bias value V_B for the slowdown command value V_D is gradually decreased in succession from a point of time t_1 indicated in FIG. 7, thereby the correct the terminal-floor slowdown command speed V_S to follow the pattern segment b-d as indicated by a solid line in FIG. 7. In this way, even when the terminal-floor slowdown command signal V_S has been selected by the microcomputer 90, the comfortable ride near the level of the terminal floor can be maintained and floor arrival precision can be obtained.

Referring again to FIG. 7, when the normal speed command signal V_N normally decreases gradually near the terminal floor, it changes along a normal pattern segment c - d - e, while the terminal-floor slowdown command signal V_S changes along a pattern segment a - b - f. Accordingly, the relationship between V_N and

V_S becomes $V_N<V_S$, and Vis selected for the final speed command signal V_F.

When the signal V_N does not follow the normal pattern near the terminal floor, for example, when it changes along a segment c - b - g, $V_N=V_S$ holds at the time t_1, and the signal V_S is selected. This signal V_S thereafter changes along pattern segments b - d - e.

That is, the slowdown command signal V_S becomes:

$V_S=V_D+V_{BO}$ for a segment a - b,

$V_S=V_D+V_B$ for a segment b - d,

$V_S=V_D$ for a segment d - e. Here, $V_D=\sqrt{2\beta_A R_B}$ holds, V_{BO} indicates the initial value of the bias value $V_B$and the bias value V_B is the value which gradually decreases from the initial value V_{BO} to the final value zero in time correspondence and which assumes $V_B=V_{BO}$ at the time t_1 and $V_B=0$ at a time t_2 in FIG. 7.

Now, the calculation of the bias value V_B for generating a signal as indicated by the segment b - d in FIG. 7, that is, the step **23** in FIG. **5** will be described with reference to FIG. **8** by means of which the terminal-floor slowdown command signal V_S is corrected by adding a predetermined bias value to the slowdown command value V_D.

A step **230** is a decision step for proceeding to a step **231** when the flag CHG is "1", namely, $V_N \geqq V_S$ holds, and for proceeding to a step **232** when it is not "1".

At the step **231**, the bias value V_B is set to the preset constant value V_{BO}, and a counter I which counts a value N corresponding to a time interval $t_2 - t_1$ (FIG. 7) is initialized to zero.

The step **232** is a decision step which compares the value of the counter I with the preset constant value N and which is followed by a step **233** for I<N and by a step **234** for I≧N.

At the step **233**, the bias value V_B is extracted from the table of the ROM **93** in FIG. **2** in correspondence with the value of the counter I, and the counter I is incremented by one. In the table, values V_{BO}- ΔV, V_{BO} - 2 ΔV, . . . and V_{BO}N ΔV are stored in the order of addresses, and a relation of V_{BO}=N ΔV is held. ΔV is a unit decrement value for gradually decreasing the bias value V_B in time correspondence.

At the step **234**, the bias value V_B is set to zero.

Thus, according to the flow chart of FIG. **8**, when $V_N<V_S$ holds, the flag CHG is a value other than "1", and the bias value V_B is V_{BO}. Accordingly, the calculated result of the terminal-floor slowdown command signal V_S becomes the segment a - b - f in FIG. 7. On the other hand, when $V_N \geqq V_S$ holds, the flag CHG is set to "1". Therefore, the bias value V_B decreases at the rate of ΔV per unit time during a fixed time interval (corresponding to the comparison reference value N for the counter I), and it becomes $V_B=0$ upon lapse of the fixed time interval.

The initial value V_{BO} of the bias value V_B is determined as follows.

Letting T_a denote the response delay time of the terminal position detector **13**, T_b a delay time until the microcomputer **90** receives the output **13***a* of the terminal position detector **13**, and T_c a delay time until the signal V_N calculated by the microcomputer **80** is transmitted to the microcomputer **90**, a residual distance error ΔR involved in the calculated residual distance becomes:

$\Delta R = v(T_1+T_2+T_3)$

Here, v denotes the speed (for example, rated speed) of the cage **1**.

Accordingly, letting R denote a distance which is required for slowing down the cage from the full-speed running to the stop thereof, the initial value V_{BO} of the bias value V_B may be set as follows:

$V_{BO}=\sqrt{2\beta_A(R+\Delta R)} - \sqrt{2\beta_A R}$ However, the initial value V_{BO} is made larger than a value obtained with the aforementioned equation so as to prevent the terminal-floor slowdown command value $V_S$from being erroneously selected for the normal operation of the terminal-floor slowdown running. Herein, an excessively large initial value V_{BO} enlarges a floor arrival error developing when the terminal-floor running operation is performed with the terminal-floor slowdown command signal V_S. Therefore, the initial value V_{BO} is set within a range within which the floor arrival error does not become very large.

The normal speed command signal V_N and the slowdown command value V_D mentioned above are calculated as $V_N=\sqrt{2\beta_A R_A}$ by the computer **80** and as $V_D=\sqrt{2\beta_A R_B}$ by the computer **90**, respectively. Accordingly, $V_N=V_D$ will hold if the residual distances R_A and R_B have no difference and the calculating cycle of the microcomputer **80** is equal to that of the microcomputer **90**.

While the foregoing embodiment has been described as to the case where the intitial value of the bias value V_B is the constant value V_{BO}, a plurality of initial values may well be prepared so as to select any of them in accordance with the residual distance.

As described above, according to this invention, when a normal speed command signal correctly follows the desired normal pattern and decreases gradually as a cage approaches a terminal-floor, a comfortable ride in a cage and the floor arrival accuracy of the cage are provided. Where the normal speed command signal does not follow the desired normal pattern due to an abnormality, the cage can be caused to safely arrive at the terminal floor by the use of a terminal-floor slowdown command signal calculated to change the normal pattern and then follow the normal pattern for at least a final portion until the cage arrives at the terminalfloor, thus maintaining a comfortable ride and providing precision in the arrival at the terminal-floor.

What is claimed is:

1. An elevator control apparatus for controlling operation of a cage in an elevator system, said elevator control apparatus conpirising:

means for generating a normal speed command signal having a normal pattern providing gradually decreasing terminal speed as the cage approaches a level of a terminal floor;

means for generating a terminal-floor slowdown signal including means for calculating a slowdown command value on the basis of actual residual distance to the level of the terminal floor and means for determining a bias value, the slowdown command value and bias value being used in generating the terminal-floor slowdown command signal and providing a normal pattern generally similar to the normal pattern of the normal speed command signal and separated therefrom by a magnitude determined by the bias value;

means for comparing the normal speed command signal and the terminal-floor slowdown command signal;

means for choosing the normal speed command signal as a final terminal slowdown command signal for controlling terminal speed of the cage when, based on comparing the command signals, the normal speed command signal is less than the terminal-floor slowdown command signal, or

the terminal-floor slowdown command signal as the final terminal slowdown command signal for controlling terminal speed of the cage when, based on comparing the command signals, the normal speed command signal is not less than the terminal-floor slowdown command signal; and

means for correcting the terminal-floor slowdown command signal when chosen as the final terminal slowdown command signal by changing the bias value used in generating the final terminal-floor slowdown command signal;

whereby the final terminal slowdown command signal follows at least a final portion of the normal pattern of the normal speed command signal.

2. An elevator control apparatus according to claim **1**, wherein said normal speed command signal generating means and said terminal-floor slowdown command signal generating means are included in independent computers performing respective calculations at predetermined calculating cycles for generating the corresponding command signals, and the bias value is set to a value greater than an error in the normal speed command signal attributed to a delay time by one of said computers in generating the normal speed command signal.

3. An elevator control apparatus according to claim **1**, including a terminal position detector providing an output signal when the cage has approached to a predetermined actual residual distance from the level of the terminal floor and means responsive to the output signal of said terminal position detector for setting the actual residual distance and for determining the gradually decreasing actual residual distance as the cage moves closer to the level of the terminal floor wherein the bias value is set to a value greater than an error in the terminal-floor slowdown command signal attributed to an operation delay time of said terminal position detector and a delay time in the output signal of said terminal position detector being received by said actual residual distance determining means.

4. An elevator control apparatus according to claim **1** wherein when the terminal-floor slowdown command signal is chosen as the final terminal-floor slowdown command signal, the bias value is set according to a successively decreasing function with respect to time, and the slowdown command value is addd to successively decreasing bias values in generating the final terminal-floor slowdown command signal.

5. An elevator control apparatus according to claim **4** wherein said terminal-floor slowdown command signal generating means determines the successively decreasing bias values by successively subtracting a fixed decrement value from a preset initial bias value every unit time.

6. An elevator control apparatus according to claim **5** wherein said terminal-floor slowdown command signal generating means includes memory means for storing a large number of said successively decreasing bias values and means for successively reading out the stored bias values from said memory means in the order of magnitudes.

7. An elevator control apparatus for controlling operation of a cage in an elevator system, said elevator control apparatus comprising:

means for calculating a residual distance from the cage to a level of a terminal floor and for generating a normal speed command signal corresponding to the residual distance and having a normal pattern providing gradually decreasing terminal speed as the cage approaches the level of the terminal floor;

a terminal position detector providing an output signal when the cage has approached to a predetermined actual residual distance from the level of the terminal floor;

means responsive to the output signal of said terminal position detector for setting the actual residual distance and for determining the gradually decreasing actual residual distance as the cage moves closer to the level of the terminal floor;

means for generating a terminal-floor slowdown command signal including means for receiving the actual residual distance determinations from the residual distance determining means and for calculating a slowdown command value on the basis thereof, and means for determining a bias value, the slowdown command value and bias value being used in generating the terminal-floor slowdown command signal and providing a normal pattern generally similar to the normal pattern of the normal speed command signal and separated therefrom by a magnitude determined by the bias value;

means for comparing the normal speed command signal and the terminal-floor slowdown command signal;

means for choosing the normal speed command signal as a final terminal slowdown command signal for controlling terminal speed of the cage when, based on comparing the command signals, the normal speed command signal is less than the terminal-floor slowdown command signal, or

the terminal-floor slowdown command signal as the final terminal slowdown command signal for controlling terminal speed of the cage when, based on comparing the command signals, the normal speed command signal is not less than the terminal-floor slowdown command signal; and

means for correcting the terminal-floor slowdown command signal when chosen as the final terminal slowdown command signal by changing the bias value used in generating the terminal-floor slowdown command signal;

whereby the final terminal slowdown command signal follows at least a final portion of the normal pattern of the normal speed command signal.

* * * * *